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(71) Applicant
Glass Incorporated International
(Incorporated in the USA - California)
5154 "F" Street, Chino, California 91710,
United States of America

(72) Inventors
Albert Lewis

(74) Agent and/or Address for Service
Pollak Mercer & Tench
High Holborn House, 52-54 High Holborn, London,
WC1V 6RY, United Kingdom

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(54) Glass composition and batch blend for its production

(57) A glass composition, especially suitable for glass fibre manufacture and having good fiberizing characteristics and good physical properties, typically contains, by weight, 40.0% to 65.0% silica, 4.0% to 11.0% alumunum oxide, 6.0% to 20.0% sodium oxide, 5.0% to 8.0% magnesium oxide, 6.0% to 17.0% calcium oxide, 4.0% to 12.0% ferrous and ferric oxides, and 0.0% to 7.0% potassium oxide.

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GLASS COMPOSITION AND BATCH BLEND FOR ITS PRODUCTION

This invention relates to glass compositions and to batch blends for their production. Glass compositions according to the invention and fibres made from them can have good fiberizing characteristics, high strength, high modulus of elasticity and high durability at high temperatures.

There has been a demand for fibre glass compositions which can be successfully formed into fibres, particularly for use in insulation and acoustical products, and as reinforcements for other materials where high strength, high modulus of elasticity and high temperature resistance are important. The problems of achieving these characteristics at low cost have long been recognized in the glass art; however, no completely satisfactory composition has been available for forming long glass fibres having desired characteristics. High temperature glass compositions have heretofore been produced, but they are subject to the drawbacks of having a short working temperature range or being too expensive to produce due to the high costs of the raw material or energy requirements.

The present invention provides a glass composition useful for forming glass fibres, the composition comprising:

SiO_2 in an amount ranging from about 40.0 to about 65.0 weight percent;

Al_2O_3 in an amount ranging from about 4.0 to about 11.0 weight percent;

Na_2O in an amount ranging from about 6.0 to about 20.0 weight percent;

K_2O in an amount ranging from about 0.0 to about

7.0 weight percent;

CaO in an amount ranging from about 6.0 to about 17.0 weight percent;

MgO in an amount ranging from about 5.0 to about 8.0 weight percent; and

FeO and Fe_2O_3 in a combined amount ranging from about 4.0 to about 12.0 weight percent.

The invention also provides a batch blend to produce a glass composition useful for forming glass fibres, the blend comprising:

at least one of basalt, fly-ash, perlite, zeolite and slag, or in an amount ranging from about 55 to about 95 weight percent;

sand in an amount ranging from about 5 to about 31 weight percent;

soda ash in an amount ranging from about 5 to about 22 weight percent;

limestone in an amount ranging from about 5 to about 10 percent;

potash in an amount less than about 9 weight percent; and

zirconia in an amount less than about 10 weight percent.

The invention can provide a glass which possesses properties lacking in glasses of the prior art. Thus, the glass of this invention can have insulation and acoustical properties, high strength and a high modulus of elasticity.

This invention can also provide a glass which has high strength and can be drawn into long, stable glass fibres.

The glass of the present invention is capable of being formed into fibres for insulations and acoustical products using the centrifugal rotary process, and/or can be drawn continuously into fibre for roving or

parallel mat. The glass can have high strength and high durability at high temperature. On fibre forming system is set forth in US Patent 3219425. The material of this present invention differs from other high temperature resistant glasses in that, unlike those used heretofore, the material of the invention can have good resistance to devitrification and requires lower processing energy. The present glass can also have improved insulation and strength characteristics. It can be relatively easy to melt and can require very little refining to free it from impurities, allowing continuous or discontinuous fibres to be produced with relative ease.

The glass of the present invention may be used in any area where high strength is required. This includes its use in a resinous matrix as a reinforcement for inorganic as well as organic matrices, and as a reinforcement for asphaltic products.

The present invention can provide for a reduction in cost of approximately 20% due to the use of less expensive raw materials and lower energy usage to process it into glass. In addition, it has been found that less binder is often required than in known, commercially available compositions, this being due to the improved surface and high strength of the fibre.

Compositions according to the present invention can have the following compositions by weight:

about 40.0% to about 65.0% silica,
about 6.0% to 11.0% aluminum oxide,
about 6.0% to 20% sodium oxide,
about 0.0% to 7.0% potassium oxide,
about 5.0% to about 8.0% magnesium oxide, and
about 4.0% to about 12.0% ferrous and ferric oxides.

Trace impurities may also be present in the glass but occur in such small quantiti s that they do not affect the composition .

The glasses of the present invention can be prepared by continuously melting of the batch raw material within the following approximate ranges at temperatures of between about 2600 and about 2900 °F (1427 and 1593°C) in conventional refractory containers. The batch composition ranges may be based upon the following materials giving the proportion by weight percent of the components:

Basalt	55	-	95
Sand	5	-	22
Soda Ash	5	-	22
Limestone	5	-	10
Potash	0	-	9
Zirconia	0	-	10

The glass compositons of this invention can have a liquidus temperature below 1200 °C and a log viscosity of (2.5) at approximately 1150 °C. These glasses are therefore suitable for glass forming. The glasses of this invention, with relatively large amounts of iron oxides, seem to have improved chemical durability. The batch can be melted in a state-of-the-art fossil fuel or electric furnace.

The batch components may be weighed in a dry powder of granular form and mixed in a conventional or pneumatic mixer. The dry batch may then be dampened with water to prevent loss from dusting while the batch is being transferred to the furnace, or it may be used dry. The batch may then be charged into the furnace which has already been brought to the desired melt temperature. Mechanical stirring of the batch in the furnace is not normally necessary since the natural convention currents, which are formed during the

melting process, act to provide circulation. Alternatively or in addition, pneumatic mixing may be used. Samples of glass may be taken from the furnace at periodic intervals to determine when the glass has reached the uniform composition. This is generally after the sand, which is last to melt completely, has dissolved.

The glass may then flow directly to a bushing for fibre production if a direct melt process is used or the glass may be cooled to a frit or pellet form and then remelted in a fibre bushing if a pellet feeding process is utilized (flame attenuation).

The molten glass can be formed into insulation and acoustical fibres using the centrifugal rotary process or the flame attenuation process. In the case of the flame attenuation process, the fibres are formed from previously made pellets. The pellets are remelted in a small, remelt furnace. By gravity the glass flows through small holes (100-200) in the bottom of the furnace. The fibres are reduced in diameter by mechanically pulling them in sets of pull rolls. A further and final attenuation is achieved by blowing the fibre by a hot, gaseous blast as they emerge from the pull-rolls. The fibres are gathered into a mat on a chain conveyer. Fibre diameter in the range of approximately 4 microns is achievable with the process.

In case if the centrifugal rotary process similar to the process described in US Patents 3190736 and 3219425, the glass flows from the melter directly into the forehearth of the furnace and then into a single hole bushing. From the orifice of the bushing the glass flows in a continuous stream into a high speed, rotating disc. Due to the high centrifugal speed, sufficient force is created to force the glass through small holes (approximately 10,000) in the side of the

disc. As the glass passes thr ugh th holes in the form of a small stream, it is furth r att nuated into smaller diameter fibres using a cold and/or hot gaseous blast. The resultant fibres are collected on a chain conveyor as a mat which conveys it through the balance of the manufacturing process. Fibre diameters in the range of approximately 5 to 6 microns are normally made using this process. Both of the above processes may be sued to manufacture sub-micron fibres.

The molten glass can also be drawn into fibres on a conventional drawing wheel at speeds up to 12,000 feet per minute (61 m s^{-1}) and temperatures of between about 1204 and about 1260 °C. Speeds of between about 5000 and about 10,000 feet per minute (26 and 51 m s^{-1}) are preferred in order to give optimum filament properties.

The fibres may be drawn from about 0.0001 to about 0.004 inch (2.54 to 102 μm) in diameter, although diameters of between about 0.00035 and 0.0004 inch (8.89 to 10.2 μm) are preferred.

To further illustrate the invention, the following examples are presented. The raw materials are given in pounds and the glasses in oxides by weight percent:

The following typical batches were mixed in a dry granular form as discussed above and melted in a conventional refractory furnace at a temperature between 1425 and 1600 °F (774 and 871 °C). The resultant glasses were successfully fiberized into continuous and glass wool fibres:

TYPICAL BATCH BLENDS

Basalt	90	90	90	90	95	90	90	90	70	70	65	60	60	59.0	55.0
Soda Ash		5	10						10	18	9	9	18	15.0	20.5
Lime-stone					5	5	10							3.5	
Sand	5	5		10		5				12	26	31	22	22.0	23.0
Potassium Carbonate															7.0
Boric Acid	5														
Glass Cullet								10	20						

NOTE: Fly-ash, perlite, zeolite or slag may be substituted for basalt.

TYPICAL GLASS COMPOSITION

OXIDES	WEIGHT PERCENT
SiO_2	40.0 - 65.0
Al_2O_3	6.0 - 10.0
Na_2O	6.0 - 20.0
K_2O	0.0 - 7.0
CaO	6.0 - 10.0
MgO	5.0 - 8.0
Fe_2O_3/FeO	4.0 - 9.0
TiO_2	1.0 - 3.0

The glass batch used to prepare these compositions contains large amounts of iron oxide. The main raw materials that may be used in these glass batches are slags, fly-ash, perlite, zeolite or basalt.

Other glass compositions which may be formed into fibres with good r sults are listed in the following

examples.

EXAMPLE 1

OXIDES	WEIGHT PERCENT
SiO_2	44.6
Al_2O_3	9.7
Na_2O	12.4
K_2O	0.8
CaO	16.3
MgO	6.8
FeO & Fe_2O_3	7.8
TiO_2	1.9

EXAMPLE 2

OXIDES	WEIGHT PERCENT
SiO_2	47.9
Al_2O_3	10.9
Na_2O	13.9
K_2O	0.8
CaO	8.2
MgO	7.6
FeO & Fe_2O_3	8.7
TiO_2	1.9

EXAMPLE 3

OXIDES	WEIGHT PERCENT
SiO_2	53.8
Al_2O_3	9.3
Na_2O	13.6
K_2O	0.7
CaO	6.9
MgO	6.5
FeO & Fe_2O_3	7.4
TiO_2	1.7

EXAMPLE 4

OXIDES	WEIGHT PERCENT
SiO_2	55.4
Al_2O_3	9.2
Na_2O	11.7
K_2O	0.7
CaO	9.0
MgO	6.4
FeO & Fe_2O_3	7.3
TiO_2	1.7

EXAMPLE 5

OXIDES	WEIGHT PERCENT
SiO_2	58.4
Al_2O_3	9.7
Na_2O	7.7
K_2O	0.7
CaO	7.3
MgO	6.7
FeO & Fe_2O_3	7.8
TiO_2	1.8

CLAIMS

1. A glass composition useful for forming glass fibres, the composition comprising:

SiO_2 in an amount ranging from about 40.0 to about 65.0 weight percent;

Al_2O_3 in an amount ranging from about 4.0 to about 11.0 weight percent;

Na_2O in an amount ranging from about 6.0 to about 20.0 weight percent;

K_2O in an amount ranging from about 0.0 to about 7.0 weight percent;

CaO in an amount ranging form about 6.0 to about 17.0 weight percent;

MgO in an amount ranging from about 5.0 to about 8.0 weight percent; and

FeO and Fe_2O_3 in a combined amount ranging from about 4.0 to about 12.0 weight percent.

2. A glass composition according to claim 1, in which the amount of K_2O is from 0.0 to 3.0 weight percent.

3. A glass composition according to claim 1 or 2, the composition consisting essentially of:

SiO_2 in the amount of about 54.0 weight percent;

Al_2O_3 in the amount of about 9.3 weight percent;

Na_2O in the amount of about 14.0 weight percent;

K_2O in the amount of about 0.7 weight percent;

CaO in the amount of about 7.0 weight percent;

MgO in the amount of about 6.5 weight percent;

FeO and Fe_2O_3 in the combined amount of about 7.4 weight percent; and

less than about 1.8 weight percent TiO_2.

4. A glass composition according to claim 1 or 2, the composition consisting essentially of:

SiO_2 in the amount of about 54.8 weight percent;

Al_2O_3 in the amount of about 9.0 weight percent;

Na_2O in the amount of about 16.0 weight percent;

K_2O in the amount of about 0.7 w ight percent;

CaO in the amount of about 5.8 weight percent:

MgO in the amount of about 3.6 weight percent;

FeO and Fe_2O_3 in the combined amount of about 8.3 weight percent; and

TiO_2 in the amount of about 1.6 weight percent.

5. A glass composition according to claim 1 or 2 the composition consisting essentially of:

SiO_2 in the amount of about 53.0 weight percent;

Al_2O_3 in the amount of about 9.0 weight percent;

Na_2O in the amount of about 14.0 weight percent;

K_2O in the amount of about 0.35 weight percent;

CaO in the amount of about 6.8 weight percent;

MgO in the amount of about 7.0 weight percent;

FeO and Fe_2O_3 in the combined amount of about 8.0 weight percent; and

TiO_2 in the amount of about 1.7 weight percent.

6. A glass composition according to claim 5, in which the amount of Na_2O is instead 40.0 weight percent.

7. A batch blend to produce a glass composition useful for forming glass fibres, the blend comprising:

at least one of basalt, fly-ash. perlite, zeolite and slag, in an amount ranging from about 55 to about 95 weight percent;

sand in an amount ranging from about 5 to about 31 weight percent;

soda ash in an amount ranging from about 5 to about 22 weight percent;

limestone in an amount ranging from about 5 to about 10 percent;

potash in an amount less than about 9 weight percent; and

zirconia in an amount less than about 10 weight percent.

8. A batch blend according to claim 7, in which the amount of sand ranges from about 5 to about 22 weight percent.

9. A batch blend according to claim 7 or 8, in which the amount of the the first-mentioned ingredient ranges from about 70 to about 55 weight percent.

10. A batch blend according to any of claims 7 to 9, in which the first-mentioned ingredient is basalt.

11. A batch blend according to any of claims 7 to 10 and substantially free of boron.

12. A glass composition substantially as hereinbefore described in any of examples 1 to 5.

13. A batch blend substantially as hereinbefore described as a typical batch blend.

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